Independent Review of the Scientific Management Recommendations
in the
June 1998 Large Coastal Shark Evaluation Workshop Report

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UNITED STATES DISTRICT COURT
FOR THE MIDDLE DISTRICT OF FLORIDA
TAMPA DIVISION

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Statement: I have reviewed the June 1998 Large Coastal Shark Evaluation Workshop (SEW) Report and the 50 other documents submitted by the Court for review and have come to the following conclusions regarding the scientific management recommendations contain in the 1998 SEW Report.

COURT DIRECTED QUESTION:

Response in respect to the Court requirement that, "Each reviewer must make one overall statement as to whether the scientific conclusions and scientific management recommendations contained in the 1998 SEW Report are based on scientifically reasonable uses of the appropriate fisheries stock assessment techniques and the best available (at the time of the 1998 SEW Report) biological and fishery information relating to large coastal sharks."

Response:

After extensive examination of the 51 documents provided for the review of the 1998 Large Coastal Shark (LCS) assessment and management, including the 1998 Report of the Shark Evaluation Workshop (SEW), <u>I conclude that the conclusions and management recommendations of the 1998 SEW were not based on scientifically reasonable uses of the appropriate fisheries stock assessment techniques and the best available biological and fishery information</u>. The analyses have the following deficiencies[1]:

1. The analyses used catch per unit effort (CPUE) data series that appear likely to have biases. Therefore, the conclusions drawn from various analytical models using these CPUE data may not adequately track abundance. I recommend re-running the analyses with only the best data sets, or more fully justifying use of the other data sets.
2. The analyses did not continue the use of the Maximum Likelihood Estimator (MLE) and non-Bayesian production models used in earlier assessments, and did not justify discontinuing these models. Comparison of the previous models with

[1] This review of the LCS stock analysis and management is based on the documentation presented to reviewers, and conducted without regard to other assessment and management responsibilities that exceed the capabilities of the NMFS Southeast Region. Evaluation of appropriate priorities for LCS vs. other species goes beyond the scope of this review.

the Bayesian model would have provided valuable information on model performance. The analyses did not perform a retrospective analysis. Retrospective patterns provide a significant diagnostic tool for evaluating model performance. I recommend running previous models, and performing retrospective analysis.

3. LCS distributions do not meet the production model requirement for closed populations. I recommend an evaluation of the consequences of an open population on the applicability of the model.
4. Given the analytic results presented in the 1998 Report SEW (LCS-1), I would concur with most of the management recommendations presented. However, the analytical results may change if a future analysis addresses conclusions 1-3 above. If so, management recommendations may also change.

These conclusions will be discussed in more detail in later sections of this report. The National Research Council provided advice (NRC 1998) that I used in my review.

Response in respect to the Court requirement that, "In reaching this conclusion, reviewers are expected to determine (1) whether the model used to estimate large coastal shark population abundance and demographic trends is reliable and scientifically rigorous and (2) whether the scientific conclusions and scientific management recommendations are based on a logical extension of the model's results."

Question 1. Was the model used to estimate large coastal shark population abundance and demographic trends reliable and scientifically rigorous?

Response:

<u>The Bayesian production model is a scientifically valid model but contained flaws such that it did not provide reliable and scientifically rigorous population abundance and demographic trends</u>. The model used CPUE data that appear biased and that should be excluded from analysis unless further justified. The production model applies to closed populations, and the LCS population is not closed. Comparison with other models, including age- or length-based models if data are available, and retrospective analysis would improve understanding of the model and give guidance on the reliability of the results.

Question 2 Were the scientific conclusions and scientific management recommendations based on a logical extension of the model's results?

Response:

<u>The conclusions and management recommendations were based on logical extension of the model's results</u>. The model results showed a significant decline in abundance, although the declining trend appeared to slow in recent years. At the estimated level of abundance, recovery to Maximum Sustainable Catch levels was uncertain over a 30-year time horizon. Given the model's results, the conclusions and scientific recommendations were consistent with the precautionary approach.

Responses to Directive: In addition, in reviewing the stock assessment, each reviewer may consider, consistent with his/her expertise, among other relevant considerations:

Question 1. how the stock assessment applied the Bayesian modeling approach to the available data and determined the appropriateness of using a non-age specific production model to assess a long-lived species (or species complex)?

Response:

Bayesian approaches have significant conceptual advantages for fisheries analysis, but add complexity to the models. Both quality control and providing management advice are made more difficult as complexity of models and analyses increases. However, Bayesian approaches do provide a systematic means for more fully expressing uncertainty in management advice. In particular, the potential to incorporate the uncertainty associated with structural model choices (in addition to parameter estimation uncertainty) is quite important. Bayesian models can provide quantitative estimates of the uncertainly inherent in stock assessment results. Use of Bayesian models is certainly appropriate for assessment of LCS.

I do not have any comments on the technical quality of the Bayesian analysis. Other reviewers will address that. I do suggest that the SEW participants should have more completely critiqued the model for objectivity and appropriateness. The conclusions from Bayesian models are sensitive to the choice of prior distributions chosen for the analysis. The authors of the Bayesian analysis (LCS-27, 28) provided a description of baseline and alternative prior distributions, based on information provide to them. The SEW participants, who are the experts in shark fisheries and biology, should have assessed and evaluated the prior distributions to assure that the choice of priors did not adversely affect the conclusions.

Question 2 how the stock assessment considered the availability and quality (i.e. how the series were estimated, how they were weighted for the analyses, and how they were applied as age specific indices of abundance, particularly for the MRFSS data which accounts for most of the LCS mortality in the early years, other than foreign fishing) of alternative data sets and statistical modeling approaches, including modeling approaches employed in prior shark evaluation workshops?

Response:

The lack of good data for the LCS often leads analysts to include as much information as possible in the assessment. The SEW gathered a considerable number of data sets that apply to LCS. The best index of fish abundance is one for which extraneous influences (e.g., changes in gear and seasonal coverage, changes in fishermen's behavior) can be controlled. CPUE data from commercial and recreational fisheries, if not properly standardized, do not usually provide the most appropriate index. The CPUE data series used for the LCS analysis appears to contain variability not related to changes in abundance of LCS. Changes in gear, seasonality of a fishery, catchability/selectivity, migration and other factors can cause changes in CPUE values that are unrelated to changes in abundance. The SEW participants did not document why all the data sets used meet the requirement that CPUE do not respond to extraneous influences. My evaluation of the quality of the CPUE data series occurs in Appendix A. Without better justification than currently provided in the SEW reports, several of the data sets should not be used in LCS assessment. The Marine Recreational Fisheries Statistics Survey (MRFSS) data set, in spite of some problems with species identification, is the only one that purports to represent majority of the resource distribution, and the procedure is scientifically based and peer reviewed. However, the MRFSS data have several problems; see Appendix A for more detail on the MRFSS data.

Other reviewers will address the details of the models used. I found three shortfalls with the procedures. First, models should first consider the best of the data sets and sequentially add poorer data sets to determine their impacts on the assessment. Poor data sets may qualitatively support conclusions from better data, but should not drive the analysis. Second, analysts should conduct retrospective analysis of the models. Each year of new data results in a recalculation of estimates for all past years. Retrospective patterns show bias that results from improper assumptions or bad data. Third, decision makers benefit from comparison of different assessment models that analyze the same data to help recognize poor data and to improve the quality of assessment results. In this case, models conducted and compared in 1998 should have included the Maximum Likelihood Estimator model, a non-Bayesian production model, and, if data are available, an age-structured model. Weighting with the inverse of the variance, as in the Bayesian model, is a standard approach. In the case of the Bayesian model, the weighted and unweighted CPUE data gave similar results (LCS-27).

Question 3 how the stock assessment handled and applied information relating to whether the species of LCS under consideration represent open or closed populations in each individual instance?

Response:

Recoveries of tagged LCS in Mexican (and other) waters from releases in US waters (LCS-50, 51) indicate that the LCS are not from a closed US population. Limited catch records indicate significant LCS landings occur from Mexican waters, and that blacktip sharks caught primarily by artisanal fisheries comprise the dominant component of the LCS in Mexican waters. Sandbar tag recoveries from Mexican waters make up a small (4%) proportion of the total recoveries (LCS-51). While dusky shark tag returns from Mexican waters make up 16% of total recoveries (LCS-51), they are a small component of the US harvest. Documentation provided to reviewers gives no information on species composition or magnitude of harvest from Canadian or Caribbean waters. Production models require a closed population (LCS-27, 32). Stock assessment analysts should determine the impacts of an open population on the model results.

Question 4 how the stock assessment evaluated the reliability of projections based on the above three considerations?

Response:

Addressing my conclusions concerning data quality, modeling approaches, and effects of an open population will not likely change the assessment result that LSC have undergone significant decline in abundance since the beginning of the recreational and commercial fisheries. However, the extent of the estimated decline may change if the stock assessment is redone. If so, the estimates of Maximum Sustainable Catch and recovery trajectories will also change.

Question 5 how the stock assessment evaluated the effects of extant regulations on stock trajectories, and weighted the risk of maintaining the status quo until these effects could be evaluated against the costs of an additional immediate reduction in permitted LCS landing levels?

Response:

LCS-1 described the 1997 shark regulations derived from the 1996 SEW. I found the 1999 shark regulations, derived from the 1998 SEW, on the NMFS web page. These regulations are consistent with the results of the 1998 SEW analysis, including the Bayesian production model, which indicates a low probability of population recovery at current catch levels. Re-running the stock assessment to address concerns for data quality, modeling approaches, and effects of an open population may result in different recommendations for commercial quota and recreational bag limit regulations.

I cannot evaluate the prohibition of catch for the listed protected species, as the review documents did not include information on the status of those populations. The 1998 SEW (LCS-1) made no recommendations to add any LCS species to the protected list.

Regulations prohibiting filleting at sea and enhancing species identification (1997), and separating ridgeback from non-ridgeback, setting minimum size for ridgeback LCS, and counting dead discards against the quota (1999) are appropriate regardless of the quota or bag limit.

The controversy over the status of LCS has dragged on for several years, with all management actions put on hold. Sharks, which are more vulnerable to overfishing than most fish, require an effective management program. However, the LCS abundance seems to be stabilizing, or at least declining at lower rates, so a little further delay would not likely cause serious harm while NMFS undertakes re-analysis of data and consideration of other models.

OTHER COMMENTS

1. Data

The data quality and quantity for catch and CPUE are generally poor for the LCS. Poor and incomplete data will limit the results of the analyses. However, I believe that the quality of catch data and of CPUE data will have different implications for the analyses and recommendations. CPUE data must be unbiased, because otherwise they will not represent the abundance. Catch data must represent all sources of man-caused mortality and estimates should err on the side of conservation. When questions of quality arise, questionable CPUE data must be rejected – bad data are worse than no data – while a poor but reasonable estimate of catch is better than no estimate.

Catch Data. The catch data series for LCS, for most of the duration of the fishery, has incomplete landings, no species composition, and no credible estimates of bycatch mortality and finned and discarded LCS in other fisheries. Models may not adequately represent population and fishery patterns without an estimate of all sources of man-caused mortality: reported landings, unreported landings, fins, and discarded catch mortality for any other fisheries. Leaving zero values for categories or years where no data are available, but where mortality occurred, is unacceptable – we know that zero is wrong. For example, LCS-1 (Table 2, column 5) estimates Coastal Discards only since 1993, but discarding probably also occurred in earlier years.

Various documents indicate efforts to obtain catch data from shark processing operations, but none indicate the success of this effort. The 1996 SEW recommended a special project to collect and reconstruct historical data from known fin dealers, but this project apparently did not happen. If unreported shark processing occurred prior to the requirement for catch reporting, some non-zero proxy for that catch should be developed. The SEW estimated LCS catch from Mexican waters (LCS-1), but I believe they underestimated the catch (see below). In spite of recommendations from previous SEW to obtain LCS catch data from Canadian and other waters, no data from Canadian harvest were available.

The 1998 SEW did try to estimate unaccounted for mortality in an *ad hoc* manner (LCS-1, Table 3). An alternative catch data set using a 50% increase from reported landings from 1981-1985, a 100% increase from 1986-1992, and a 10,000 fish longline bycatch recognized the concerns for unreported landings expressed by industry. While the industry believes that these adjustments are still too low, it has not provided documentation to support higher values. Nothing provided for review suggests a better procedure for these estimates.

Limited data suggest that LCS landings in Mexican Gulf of Mexico waters may represent several thousand mt. The Mexican shark landings averaged over 9,000 mt from 1976 to 1995. Since the early 1980s, Mexican LCS landings in the Gulf of Mexico ranged from 10,000-15000 mt of which 80% is artisanal (LCS-9), or about 8,000-12,000 mt. Blacktip make up about 11% by numbers of the artisanal fishery (LCS-39), and other LCS make up a small fraction. No information is given on average weight of blacktips relative to other sharks. If blacktip average the same weight as other sharks, then they make up 11% of the weight of artisanal harvest (roughly 900-1300 mt). Because blacktips are generally of larger size, they could account for a higher proportion, perhaps 2,000-3,000 mt. Remaining Mexican harvest is approximately 2,000-3,000 mt, but not likely all LCS. US landings ranged from 3,000-4,000 mt for commercial fisheries from 1990-1995 (LCS-45) and 800 mt for recreational fisheries in 1995 (LCS-13), so the Mexican landings represented a significant portion of total LCS, and especially blacktip, landings.

CPUE Data. Ideally, at least one CPUE series should represent the entire resource. Using the information in the documents provided for review, I have evaluated the CPUE data sets (Appendix A), based on information received, to determine which are suitable for use in the LCS assessment. The CPUE data sets available to assess what appears as coast-wide LCS resource limit the reliability of the conclusions. No data sets exist that represent the entire resource. Only the Marine Recreational Fisheries Statistical Survey (MRFSS) purports to represent a major portion of the resource distribution.

Most data sets are limited to a small geographic area. Therefore, even small changes in factors not related to abundance, such as changes in migration, onshore-offshore distribution, or shark aggregations on prey concentrations, can easily cause large changes in the CPUE series limited to small areas. Many fish resources contract to a central area during decreasing abundance, so CPUE indices from the margins of the distribution would show CPUE declining faster than the population as a whole. CPUE indices from the center of the distribution would decline slower than the population. If small coastal shark (SCS) abundance increased (possibly from reduced predation by LCS), then competition for hooks from SCS could cause LCS catch rates to decrease faster than actual abundance. Conversely, shift of harvest to smaller or less desirable LCS could maintain or reduce the decline of CPUE for LCS.

Fishery-independent surveys offer the best opportunity for controlling sampling conditions over time and the best choice for achieving a reliable index if they are designed well with respect to location, timing, sampling gear, and other considerations of statistically valid survey design. However, the fishery-independent CPUE series for LCS are not standardized with respect to each other, so they may not measure abundance the same way. Longline surveys used in the LCS CPUE series use either cable gear or monofilament gear, and are conducted quarterly or annually. Additionally, catch rates are so low for some data series that several fish more or less in the catch can greatly affect the overall catch rate.

Data available before 1980 account for the peak CPUE values (LCS-1, Fig 1.1), yet most are of poor quality (see Appendix A): Crooke (Rank 2), JAX (Rank 3), Port Salerno (Rank 3), VA LL (Rank 1 overall but small data sets in early period). All show extreme variability during that period. Are the data points during this period representative of abundance?

Logbook data can provide excellent data, including data for tracking CPUE. However, the logbook data must be used with extreme caution for LCS. Reef logbook requirements changed in 1993; therefore, the 1990-1992 series differ from the 1993-1995 series. Fishermen had the option from 1993-95 of recording directed sharks in a reef logbook or a shark logbook, so those data must be combined and standardized to use them – neither logbook by itself appears suitable for tracking abundance. A single logbook has been used for reef fish and sharks since 1996, but the data are not used for the analysis. LCS-1 states that weight-based reef fish/shark logbook data are suitable for numbers-based analysis, because average size has not changed much.

Length-Weight-Age Data. The Industry complained that average weight data used to convert harvest weight to numbers of fish were too low from 1988 to 1991 (LCS-51). LCS-1 (Table 1) states that the SEW used average weights for the 1986-1991 period, but felt that the average weights were too high for 1992-1993 and lowered them. Yet, average weights for blacktip (LCS-1, Table 4) and for sandbar (LCS-1, Table 5), which make up 80% of the LCS landings, remained constant from 1986 to 1993. LCS-45 states that average weights for 1986-1991 came from fisherman logbooks and weigh-out data, a data set replete with problems, and that the 1992-1993 average weights were calculated from blacktip and sandbar observations of the pelagic longline fishery which does not catch these species in a representative manner (Exhibit II, LCS-51). The inconsistencies in the average weight data set call for a reassessment of the values. I am further concerned that the length data are not obtained using a rigorous protocol to obtain random samples.

The Industry also expressed concern for a proposed new age at maturity of 30 years and a new maximum age at 60 years. LCS-1 states that original estimates of 15 and 30 years for age at maturity and maximum age, respectively, are now generally accepted.

2. Models

Use of the Bayesian model was an important step to update and improve the modeling process. However, different assessment models should be used to analyze the same data to help recognize poor data and to improve the quality of assessment results, especially when data are limited or of poor quality. The 1998 analysis did not use a MLE or a non-Bayesian production model in 1998 assessment, so missed an opportunity for comparison. Experience may demonstrate superiority of one model, and justify exclusion of other models. The 1998 SEW did not explain why it used only the Bayesian model.

Bayesian methods do not generally result in different estimates of parameters compared to non-Bayesian methods. Other model techniques can also estimate variance of parameters or results using assumptions of normal distributions. The probability distribution of the estimates may differ, however. Bayesian methods provide better probability distributions for non-normal parameters, and are important for risk management decisions. Because the Bayesian and non-Bayesian methods should estimate similar values for parameters, dissimilar results indicate poor parameter estimation. For example, the production model used in the 1996 SEW (LCS-32) did not use the alternative catch history that accounted for underreporting of catches prior to the Shark Fishery Management Plan, because doing so made produced an estimate with "an unreasonable large number of sharks in the sea in 1981 and throughout the time series." Yet, a similar production model with Bayesian estimation (LCS-1, 27) used the alternative catch history with acceptable results. Also, the intrinsic rate of increase used in the 1996 model was substantially different from that in the Bayesian model.

Controversy exists on the applicability of production models in general. Production models provide an analytical simplicity that may give good decision-making ability. Production models provide results useful with control rules used to meet requirements of the Magnuson-Stevens Fishery Conservations and Management Act. On the other hand, production models are not realistic, and cannot use important information such as age and length data. More complex models better quantify the unknown aspects of the system and better address the long-term management consequences. To the degree possible, I prefer use of age-structured models, or length-based models. For example, CPUE that tracks numbers of fish would not adequately show the effects of increased harvest of small fish and the decreased harvest of large fish, as apparently has happened for the LCS (LCS-46). In this case, spawning potential would decline much faster than the decline of CPUE in numbers.

Production models require closed populations. These models assume that all individuals are equally vulnerable to the fishing gear, and that CPUE is directly proportional to the population present. If immigration or emigration occurs, or if fishing occurs beyond the CPUE index area, then CPUE no longer represents the population. As pointed out by the industry position paper (LCS-51) and several other documents, the LCS resource in the US EEZ is clearly not closed, as the fish move through Mexican waters, Canadian waters, and the Caribbean. Stock analysts must determine how this violation affects the stock assessment results. The LCS resource is not even closed in respect to the CPUE series available for analysis. Generally, each series represents a very small area, so the series tracks the abundance only in that area. Is this abundance related more to overall abundance or to shifts in distribution over time? Fortunately, some of the best CPUE series (see Appendix A) occur over a fairly long time and in different areas, so that the composite CPUE may track population abundance.

The industry has expressed concern (LCS-51) that personnel and software from the Miami lab of the SEFSC were not available at the 1998 SEW meeting. This is not a problem by itself. If NMFS provided knowledgeable staff and the software appropriate to the models considered, then the SEW had ample information. Ideally, the knowledgeable staff would include those with tenure in the process to add continuity. The industry apparently believed that a conflict of interest occurred when the Wildlife Conservation Society performed the 1998 stock assessment. The analysts, both widely respected, used data provided by NMFS, documented their assumptions, and used standard procedures in the Bayesian model. While other reviewers will comment on the details of the model, I did not see any signs of bias in the analysis. However, NMFS and the SEW have a responsibility to thoroughly review the model for appropriateness and objectivity. I also believe that an age-structured analysis should have been performed, for any LCS species for which adequate age data existed. However, nothing I saw in the documentation indicated that such age data existed. A composite age composition of a multi-species complex with different demographics would be difficult to construct.

The industry points out that stable CPUE trends in recent years do not mirror the results of the Bayesian model, which show a continued decline in estimated abundance. Whether the CPUE trends or the results of the Bayesian model would show the same pattern if redone with the best CPUE data remains to be seen. However, the results of the Bayesian model show a slowing decline in the most recent years, not inconsistent with stable abundance (given the width of the 95% confidence interval in Figure 4 of LCS-27). Very few stock assessments will show CPUE exactly tracking the abundance pattern. LCS-1 states that the LCS stock would have to double or half to detect a change in CPUE with reasonable certainty. The point of stock assessment models is to integrate all data into a composite result, which more accurately tracks actual abundance than do individual indices. CPUE alone may not adequately track abundance on a year-to-year basis.

The industry also pointed out that the CPUE and model results show an abundance decline of LCS since the 1970s and early 1980s, before the beginning of the commercial shark fishery. Several factors, including climate change, the recreational harvest, or bad data, could have caused the apparent decline. If the best available data demonstrate an abundance decline to below overfished thresholds, then NMFS must respond by restricting harvest.

The industry questioned the weighting procedures used in the model. Relative weights are used to control the emphasis on different model components used in the estimation. Weights should correspond to the level of information presented in the data. Weighting with the inverse of the variance, as in the Bayesian model, is a standard approach. Models generally use the sample variance for weighting, which generally underestimates actual variance. In some cases, analysts may increase the variance with *ad hoc* methods to recognize unaccounted for variability, or may decrease the variance to give greater weight to information of high importance. Analysts must have good reason to adjust weighting, to avoid perceptions of adjusting the results. In the case of the Bayesian model, the weighted and unweighted CPUE data gave similar results (LCS-27).

State of the art modeling with good data by best scientists may provide poor results if biased data or parameters are used. Northern cod assessments systematically overestimated biomass and led to over harvest (Sinclair et al. 1996). Pacific halibut assessments systematically underestimated biomass (Sullivan at al. 1999). If good scientists with good data make major errors in abundance estimation, then we can reasonably conclude that poor data series available to good scientists for the LCS assessment will have a high probability of wrong results; managers should use the results with caution. Each year of new data results in a recalculation of estimates for all past years. A retrospective analysis examines the consistency of successive estimates as the analysis adds new data (Parma 1993). Retrospective analyses used for northern cod and Pacific halibut pointed out the trends of errors, which led to revisions in the models that reduced the retrospective errors and improved management recommendations. Retrospective analyses of the LSC assessments would provide valuable insight.

3. Management

The International Code of Conduct for Responsible Fisheries, to which the U.S. is signatory, states that fisheries management organizations should widely apply a precautionary approach to conservation, management and exploitation of living aquatic resources to protect them and preserve the aquatic environment, taking account of the best scientific evidence available. Critically, the absence of adequate scientific information should not be used as a reason for postponing or failing to take measures to conserve target or non-target species and their environment.

During the development of the shark fisheries, not even the most rudimentary management measures, such as basic catch reporting, were established. Sharks are well known to have a life history that makes them more vulnerable than most fish species to overfishing, and requires more precautionary measures to maintain a sustainable fishery. The inadequate data described above certainly limit the reliability of conclusions drawn from them. These earlier management failures, however, do not relieve NMFS from a more important responsibility to properly manage the current situation. Insufficient information is no excuse for not taking action. Given uncertainty, as is the case for LCS, precaution dictates erring on side of conservation. Putting off protective regulation of natural resources while waiting for adequate information could lead to resource destruction. Overharvest of a fishery resource during a regulatory delay could lead to overfishing and an overfished condition. With underharvest, the resource remains for possible later exploitation.

Such precaution leads to a management philosophy of “slow up and fast down” for quotas. In times of increasing estimated abundance, quotas should go up at a rate slower that the rate of estimated population increase. In times of decreasing estimated abundance, the quotas should go down faster than the estimated rate of population decrease. This guards against overestimation of abundance and possible overharvest. The high probability of a wrong assessment discussed earlier dictates caution in harvesting the full amount derived from model results, especially in situations with poor data.

LCS-1 states that NMFS implemented several protective measures for LCS in 1997 as a result of the 1996 SEW:

- Reduced the annual quota to 1285 mt dw;
- Reduced recreational bag limit to two fish;
- Prohibited directed fishing for sand tiger and bigeye sand tiger;
- Prohibiting filleting at sea; and
- Reemphasized the requirement for species-specific identification.

The 1999 management actions resulting from the 1998 SEW call for more restrictions on the LCS fishery:

- Reducing the commercial quota to 816 mt dw (620 for ridgeback and 196 for non-ridgeback);
- Reducing recreational bag limits to one shark per vessel per trip (plus one Atlantic sharpnose, a SCS, per person);
- A minimum size for commercially-caught ridgeback LCS and for all recreationally-caught LCS sharks;
- Sharks discarded dead count against the quota; and

- Expanding the protected species (prohibited directed fishing) for LCS.

The Industry Position (LCS-51) states that inadequate time was given to see effects of an approximately 50% catch reduction put into effect in 1994 following implementation of the Shark Fishery Management Plan, and that no further restrictions should have occurred. The two assessments (1996 and 1998) since then have added new information and new techniques. NMFS has a responsibility to use updated information in its management and to modify regulations using the new information. If new information indicates a change in the stock condition, NMFS must react accordingly. However, I believe that more justifiable management measures will result by applying the recommendations for data and models made earlier.

Determination of the commercial quota and the recreational bag limit depends largely on the results of assessment models, for which I have made some recommendations for improvement. I have no information to assess the utility of prohibiting catch of species on the protected species list, as we were provided no documents describing justifications for protection. The 1998 SEW (LCS-1) made no recommendations to add any LCS species to the protected list. The SEW considered the night shark for the prohibited list, but determined that it was premature (LCS-1).

The other actions make good management sense regardless of abundance and I support them: prohibiting filleting at sea and enhancing species identification (1997 regulations), and separating ridgeback from non-ridgeback, minimum size for ridgeback LCS, and counting dead discards against the quota (1999 regulations).

RECOMMENDATIONS

The 1998 SEW made a number of research recommendations for Atlantic sharks. If NMFS implements these recommendations, the scientific environment for LCS will improve markedly. In addition, I have the following recommendations.

The controversy over the status of LCS has dragged on for several years, with all management actions put on hold. Sharks, which are more vulnerable to overfishing than most fish, require an effective management program. However, the LCS abundance seems to be stabilizing, or at least declining at lower rates, so a little further delay should not cause serious harm while NMFS re-analyzes data and considers of other models.

Fishery-independent surveys offer an excellent opportunity for achieving a reliable index of abundance. I recommend establishing a regional, standardized longline survey, with single agency in charge, but with wide participation from other agencies. NMFS should support this long-term data collection, using appropriately calibrated vessels, and statistically valid surveys well designed with respect to location, timing, sampling gear, and other considerations. A long time series provides much more value than a short series, so the sooner the surveys start, the sooner useful data become available. The longline surveys currently conducted could form the basis for a consolidated survey.

Managing on the basis on the LCS complex obscures the species-specific and regional differences among the LCS species. The separation of ridgeback and non-ridgeback sharks is a good step toward assessment and management on an individual species basis. NMFS should also explore regional management, for example, by dividing total quota into regional subquotas that are proportional to biomass in a region. Homing tendencies, as suggested by tagging data (LCS-29), would make LCS vulnerable to local depletion, and abundance of LCS is not uniform along the Gulf of Mexico-Atlantic coast. Regional management could protect against different genetic populations of a species in the Atlantic area, and could protect species with lower productivity that occur primarily in specific regions.

I am concerned that numbers-based CPUE will obscure important changes in the demographics of LCS, such as increased harvest of pre-reproductive sharks because of declines in mature sharks. Reproductive collapse could occur even as CPUE stabilized over the short term, if the fishery catches enough pre-reproductive sharks. I recommend collecting age and length composition data using a strict protocol that assures random samples. Several documents suggest that length data were collected in a non-random way that would cause biases. Analysis should include age- or length-based methods as soon as adequate data are available.

The Shark Industry Position Statement (LCS-51) states that encouragement and support from NMFS was integral to the commercial fishery development in the 1980s. Yet, NMFS implemented no form of shark fishery management until a crisis developed. If NMFS's development role is true, then I believe that NMFS has a responsibility to the shark fishermen. Likely future restrictions, including a possibly lower TAC, will cause economic hardships for the fishermen. I recommend that NMFS work with the fishermen to institute a shark fisherman reduction program, consistent with national policies.

REFERENCES

The numbered references in this Review are to the Natural Resources Consultants, Inc. Large Coastal Shark Review Document List.

NRC. 1998. Improving Fish Stock Assessment. National Research Council, National Academy Press, Washington, D.C.

Parma, A. M. 1993. Retrospective catch-at-age analysis of Pacific halibut: Implications on assessment of harvesting policies. Pp. 247-265 in G. Kruse, D. M. Eggers, R. J. Marasco, C. Pautzke, and T. J. Quinn, II (eds.), Proceedings of the International Symposium on Management Strategies for Exploited Fish Populations. Alaska Sea Grant College Report No. 93-02. University of Alaska, Fairbanks.

Sinclair, M., R. O'Boyle, D. L. Burke, and G. Peacock. 1996. Why do some fisheries survive and others collapse? Pp. 23-35 in D. A. Hancock, D.C. Smith, A. Grant, and J. P. Beumer (eds.), Developing and Sustaining World Fisheries Resources:

The State of Science and Management: Proceedings of the Second World Fisheries Congress. CSIRO Australia.

Sullivan, P. J., A. M. Parma, and W. G. Clark. 1999. The Pacific halibut stock assessment of 1997. Inter. Pac. Halibut. Comm. Sci. Rep. No. 79. Seattle, WA.

Appendix A. Comments on CPUE data series used the 1998 LCS stock assessment

List of CPUE series used in the 1998 assessment (LCS-1)

Series	Ref - LCS	Rank*	GLM LCS	GLM Sbar	GLM Btip	Bayes LCS	Bayes Sbar	Bayes Btip	Years In Series
Brannon	47	3	X			X			86-91
Hudson	None	3	X			X			85-91
Crooke LL	40	2	X			X			75-89
Shark Obs	2,3,4	1	X	X	X	X	X	X	94-97
Jax	None	3	X			X			79,84,90
NC #	40	2	X			X			88-89
SC LL	46	1	X	X		X	X		83,94-95
Port Salerno	None	3	X			X			76-90
Tampa Bay	None	3	X			X			85-90
Virginia LL	14	1	X	X		X	X		74-93,95-97
LPS	6	2	X			X			86-97
Charter boat	49	1	X			X			89-95
Pelagic logbook	23,34	3	X	X	X	X	X	X	86-97
MRFSS, TX1	44	2	X	X	X	X	X	X	81-92
MRFSS, TX2	44	2	X	X	X	X	X	X	93-97
NMFS LL NE	24 (?)	3	X	X	X	X	X	X	86,89,91,96,98
NMFS LL SE	30	1	X	X	X	X	X	X	95-97
Reef logbook	18,19	2						X	93-97

X = used in assessment
X = if used here, could use in GLM

*Rank 1 = best data
Rank 2 = data problems – justify why OK to use, use as supporting info
Rank 3 = Serious questions with data – don't use quantitatively
See assessments of data series below

Assessment of CPUE data series

The assessments of the CPUE data series used during the 1998 SEW were based on the documents provided for this review. In many cases, the documents assumed that readers knew of or had access to the details of the sampling regimes discussed. Lack of detail made assessments difficult. The ranking of the data sets ranged from 1 = best data; 2 = apparent data problems that need more justification before using, but may supply supporting information; and 3 = apparent serious data flaws that disqualify the data from quantitative use, unless justified by additional information, but may supply supporting information.

Brannon (LCS-47). Rank = 3. Personal fish house records. This is an incomplete data set, with actual landings higher than indicated for at least two years. Not sure which states to assign landings. Catch per trip is a poor measure of abundance, as fishermen can adjust trip length to meet landing target (market) or vessel capacity. No species ID.

Hudson (No ref). Rank = 3. Personal fish house records. 1998 SEW (LCS-1) says source from LCS-47, but not mentioned in material I received. Apparently no species ID. Cannot evaluate this series.

Crooke LL (LCS-40). Rank = 2. Personal fisherman catch data. Incomplete data: missing data for sets with no catch. Very small areas are not representative of stock status, as minor migratory or distributional changes make a big difference in rates. No species ID.

Shark Observer Data. (LCS-2, 3, 4). Rank = 1. Observers. Good data collection procedure. But small sample of participating vessels (enough samples, but not enough vessels sampled) and voluntary participation do not likely represent the overall fleet. Good species ID.

Jax (LCS-1, 40). Rank = 3. Shark tournament. No specific information given for this series. In general, recreational data from tournaments are clustered, not standardized. The very small area and time period will not likely represent the stock status. No species ID.

NC # (LCS-40). Rank = 2. Observers. Catch per trip is a poor measure of abundance, as fishermen can adjust trip length to meet landing target (market) or vessel capacity. Only two years of data used because of trip limits in 1990 – two years are not enough for a trend.

SC LL (LCS-46). Rank = 1. Longline survey. Standardized methods, areas, and times. Good species ID. Allows comparison of catch rates on decade scale. Very small area is not representative of stock status, as minor migratory or distributional changes make a big difference in rates. Not standardized with other series because of different gear and seasons.

Port Salerno (LCS-1, 40). Rank = 3. Shark tournament. No specific information given for this series. In general, recreational data from tournaments are clustered, not standardized. The very small area and time period will not likely represent the stock status. No species ID.

Tampa Bay (LCS-1, 40). Rank = 3. Shark tournament. No specific information given for this series. In general, recreational data from tournaments are clustered, not standardized. The very small area and time period will not likely represent the stock status. No species ID.

Virginia LL (LCS-14). Rank = 1. Longline survey. Consistent techniques over a long period provide a good data set. Standardized for gear, area, and time. Drawbacks include low sampling during the critical 1970s and early 1980s and limited survey area. A very small area is not representative of stock status, as minor migratory or distributional changes make a big difference in rates. Not standardized with other series because of different gear and seasons. I believe that standardizing the CPUE to environmental conditions, as requested by industry, would have minimal effects compared to the effects from a limited survey area.

LPS (LCS 6). Rank = 2. Creel, telephone survey of recreational fishermen. Conducted similar to MRFSS, but no details given. Survey area is north of the center of LCS distribution. Sandbar is the least caught of surveyed sharks, and dusky are a small portion of the LCS catch. Small changes in targeting may affect LCS CPUE (note the large increase of blue shark CPUE as sandbar CPUE decreased). CPUE series may not represent abundance of overall LCS population.

Charter boat (LCS 49). Rank = 1. Survey of recreational fishermen. Very little explanation is provided in LCS 49 to explain the procedures of the charterboat data. However, as the survey was conducted by the SEFSC, I assume it was scientifically sufficient.

Pelagic logbook (LCS 23, 34). Rank = 3. Logbook data. LCS are poorly represented in the pelagic catch so CPUE is probably not representative. Most LCS found in waters < 100 m depth (LCS-40), but the pelagic shark fishery occurs in deeper water. Silky and dusky predominant the LCS catches in pelagic fisheries, but make up very small parts of the directed LCS fishery. Sandbar and blacktip are not important in pelagic catch. The report of the 1986 meeting of shark experts (Exhibit II of LCS-51) concludes that dusky, sandbar, and lemon sharks “do not lend themselves to being caught on pelagic longlines.” Many LCS are discarded from the pelagic fisheries. Discards are usually poorly represented and probably seriously underestimated in the logbook data.

MRFSS. (LCS 44). Rank 2. Recreational survey. The documentation provides no information on the procedures for estimating catches from MRFSS, Texas Parks and Wildlife Survey, or the NMFS Headboat Survey. As a result, I cannot evaluate the specific suitability of these data for LCS. In general, the MRFSS was developed as a peer-reviewed scientific protocol, and applies to a large portion of the management area for LCS. Potential drawbacks to surveys such as MRFSS with a telephone or mail component include lack of response in fear of additional regulations or in protest to past management; species misidentification; improper catch reporting; and incorrect area assignment. The CPUE series did not use species ID from shark tournaments, so why use species ID from MRFSS, (at least from phone survey component)? Several states do not use MRFSS data because of these problems. Ideally, the MRFSS should be tested periodically for various areas with a creel census-type survey to confirm accuracy. For example, NMFS could compare the 1989-1995 GOM charterboat LCS catch rate (LCS-49) with MRFSS data for that area, and the 1986-1997 Virginia-Massachusetts pelagic shark catch rate (LCS-6) with the MRFSS data for that area.

NMFS LL NE (LCS-24). Rank = 3. Longline survey. LCS-24 states that these data are inadequate for stock assessment because of discontinuities in the programs. SEW 98 (LCS-1) does not mention using data from LCS-24. Rather, the NE longline data came from unpublished NMFS data (LCS-1). I do not know if the surveys were standardized for gear, area, season, time of day, or depth. These surveys provided data for blacktip – are the catches large enough to provide a good index? VA longline did not report blacktip. Why would longline data index blacktips in NE but not in VA?

NMFS LL SE (LCS 30). Rank = 1. Longline survey. These data are from a scientifically designed survey that covered both GOM and SE Atlantic, but for only a 3-yr time series. The survey used commercially equivalent gear to maximize comparability to commercial fishery. Like other longline surveys, it suffers from a limited survey area.

Reef logbook (LCS 18, 19). Rank = 2. Logbook data. The data are incomplete for shark landings and the data must be used with extreme caution for LCS. Reef logbook requirements changed in 1993; therefore, the 1990-1992 series differ from the 1993-1995 series. The 1990-1992 directed shark trips not included in the data set used for analysis. Fishermen had the option from 1993-95 of recording directed sharks in a reef logbook or a shark logbook, so those data must be combined and standardized to use them – neither logbook by itself appears suitable for tracking abundance in these years. A single logbook has been used for reef fish and sharks since 1996. Therefore, 1993-1995 and 1996-1997 sample different populations of fishermen. LCS-1 states that weight-based reef fish/shark logbook data are suitable for numbers-based analysis, because average size has not changed much. Species identifications are available in the logbooks for sandbar, blacktip, and bull sharks. But how well do fishermen identify shark species? If blacktip data are suitable for the Bayesian analysis, they should also be suitable for the GLM analysis, but were not used there. If the blacktip data are suitable for analysis, then why are sandbar data not suitable for analysis?